Garpenberg Research Infrastructure Project for neutrinos (GRIPnu)

A Socio-economic and Industrial Study of the Consequences of constructing a World-leading Neutrino Detector in Garpenberg in Region Dalarna commissioned by Garpenberg Council

Translated from Swedish by Colin Carlile, Uppsala University March 2017

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Summary Description of the GRIPnu project

Project Leader: Hedemora Enterprise AB

Geography: North Central Sweden, Skåne-Blekinge and East Central Sweden

Type of project: National Regional funds programme, Investment Priority 1b

The industrial sector in these regions has undoubtedly great potential for growth and numerous development projects are underway including, within the framework of the EU regional development fund, to preserve and strengthen companies. Our assessment is that these efforts need to be supplemented with one or more "flagship projects", based on the Regional Smart Specialisation Strategy. It is important for existing industry outside metropolitan areas to take advantage of the nascent industrial changes, and orient them in a positive direction. The conditions at the moment are relatively good judged by the recent positive population trend due to increased immigration, with new skills, developed international contacts and new ideas clearly evident in these regions.

The national strategy for ESS, the European Spallation Source, indicates that the very significant investment in international research infrastructures that is taking place in southern Sweden will also be reflected more widely within Sweden. The GRIPnu project enables the ESS venture to add a second node which would have significant positive effects in central Sweden, and enable contacts to be established between both academia and industry. The ESS accelerator will be the world's most powerful accelerator with a beam power of 5 MW. A European research consortium ESSnuSB, within the framework of the EU COST Action, has been active since 2012, planning an ambitious world-leading research project on neutrinos, which is based upon the use of the ESS accelerator in Lund, and within which the FREIA Laboratory in Uppsala, currently is strongly committed.

ESSnuSB is launching a design study on how the ESS accelerator beam power can be doubled to 10 MW and the extra beam power, thus created, could be used to generate a uniquely intense neutrino beam simultaneously with the production of spallation neutrons for the study of materials. With this neutrino beam it will be possible to perform measurements that can solve important fundamental questions in particle physics. The two uses therefore complement each other. Globally currently there are three active and large-scale neutrino research initiatives. These are LBNE-Dune in the USA, Hyper Kamiokande (Hyper-K) in Japan, and GRIPnu in Sweden.

The ESSnuSB research consortium has members in 11 European countries. From Sweden, researchers come from Uppsala and Lund Universities and KTH in Stockholm. The neutrino beam, which would be produced at ESS in Lund, would be detected in a very large underground water detector to be installed at about 1000 m depth. The selection of the detector location requires it to be situated about 500 km from ESS, have the "right rock" and, beneficially, adjacent to a mine. It has been shown that in Garpenberg, adjacent to the mine there, would be an optimal location for the detector.

An investment in a research infrastructure corresponding to GRIPnu will in the foreseeable future take place somewhere in the world. The establishment of ESS in Lund, already a given, and conditions in Garpenberg with an active mine and suitable bedrock creates unique opportunities for Sweden to further strengthen its international position as a research nation through the establishment of GRIPnu. The research that will be conducted at the detector facility will attract scientists from all over the world, which will increase the interest for research and innovation in the Region. The establishment would have a huge positive impact on the Region's economy. A high-tech investment of about 700M€ would provoke a significant demand for and growth of the technical and industrial-oriented companies in the region around Garpenberg.

Studies of similar establishments around the world have witnessed great innovation and development of existing businesses, and have already been seen in the planning of current investment in the shape of new business opportunities for companies The implementation of the ESSnuSB project would similarly be of great importance for the development of Uppsala, where the scientific project manager for the neutrino detector project in the Garpenberg mine is based, as well as the Freia accelerator laboratory. This phenomenon can be compared to the importance of ESS and MAX IV to the Faculty Development in Lund.

The overall project objective is to actively contribute to and define quantitatively the effects of the ESS initiative in Lund as it spreads to North and East Central Sweden, which leads to an enhanced attractiveness for corporate innovation and growth. Capability would be improved and the project would be developed into a recognised positive example of cross-border cooperation, geographically of course but also between research, entrepreneurship and community development. The project objective is to build a number of collaboration platforms for open innovation, where high-tech companies, researchers and politicians work together with the construction of "infrastructure" for the future establishment of GRIPnu by defining the level of detail of the conditions for the establishment in Garpenberg.

Collaboration Parties

The project is directly related to the establishment of ESS and a European research consortium ESSnuSB, which since 2012 has worked with the planning of a research project on neutrinos based on the use of ESS accelerator in Lund. The ESSnuSB consortium has members from 11 European countries, working together in an EU COST Action project. Globally there are currently three active and large-scale initiatives in neutrino beam research. These are LBNE-Dune in the USA, Hyper Kamiokande (Hyper-K) in Japan, and GRIPnu in Sweden.

The project has direct links to FREIA at Uppsala University through the cooperation established with the ESS. FREIA contributes knowledge at the extreme forefront of research and through its involvement in ESSnuSB with international contacts.

Innovation environment

The Triple Steelix in Dalarna Smart Specialisation Strategy priority "Advanced Industry" encompasses the steel industry at its Garpenberg base. Since 2004 Innovation Environment has co-financed within the framework of Vinnova Vinnväxt (Growth Winner) Programme. Triple Steelix will contribute knowledge on the implementation of major investment projects, established contacts and networks in both industrial policy together with research actors in Garpenberg.

Stuns Foundation for cooperation between the university of Uppsala, business and society, whose aim is to strengthen the region's economic growth and sustainable development. A main task for the Stuns is to support the development of business in new areas. The aim is to contribute to the region's growth and attractiveness through competitive and growing companies. Stuns focuses on: life science, energy, and innovation and business.

IUC Syd AB is an established meeting place for industrial development, growth and cooperation. IUC Syd creates venues for learning exchanges between enterprises, research institutions, industry associations, and government organisations with an interest in the development of industry. The organisation is formed with a core of promoters from academia, research, industry and the public. IDC South is an active partner in the construction of the ESS notably by developing supplier collaboration between companies.

Dalarna University, will contribute actively in the project via its areas of strength:

- Energy, in which the university will participate in the development of energy systems for receptor and water treatment plant based on the stringent standards that a climate control facility requires.
- Materials, where the University's advanced materials laboratory can be used to produce materials that can withstand the challenges demanded for corrosion and emission.
- Complex systems and micro data analysis is a business at the University which will have the greatest long-term benefits of the establishment by participating in the collection, modelling, compilation and interpretation of large data sets. Dalarna University is well-placed that GRIPnu generates.

The Mountain School in Filipstad is a regional partner in the field of rock engineering, both practical and theoretical. Luleå University of Technology (LTU) has been the principal centre, the so-called Mountain School, for massive mountain technology since 2012. This means that both research and education is promoted in the areas of mining, metallurgy, construction and rock sciences and engineering, and that both universities work together to meet industry's skills needs. Mountain School has participated in the pilot study via one of its professors, and is a resource for the project, both in the initial stage of investigations by resource needs - and given the feasibility of implementation - the Mountain School’s technical contribution as partners in rock engineering research and geology.

GRIPnu vision when in operation.

IUC Dalarna AB will contribute by enabling regional companies to participate in both the construction and operation of the plant. IUC Dalarna operates and is actively involved in business promotion systems mainly in Dalarna and Gavle city, but also to some extent in Västmanland and Värmland. The company has long experience of development projects aimed at small and medium-sized industrial companies, with a focus on engineering and wood/construction companies. IDC also has a close cooperation with the Triple Steelix and, through this cooperation, has established relationships with both the steel industry and small and medium businesses around the steel industry. IUC Dalarna has nearly 20 years of experience in building and operating the network provider and will be a very important partner on the basis of their experience of vendor systems and knowledge/relationships with the region's industrial companies.

Hedemora municipality is involved in the community development processes that the project requires.

Industry Consortium

Initial contacts have been made to form an industry consortium with world leading companies in the mining industry, in the production of stainless steel, and its installation as well as system suppliers with expertise in installation and water purification.

Background and business environment

Background

GRIPnu stands for Garpenberg Research Infrastructure Project for neutrinos. The new particle accelerator, which is under construction at the European Spallation Source (ESS) in Lund, Sweden and is scheduled to be operational in 2019, can be used to produce an intense beam of neutrinos, which have similarities to quarks, the elementary particle. Such a beam could be used for studies of key issues related to the origin of the universe in the Big Bang, etc.

The studies are based on the neutrino beam which is transmitted about 500 km from the source in Lund to a sophisticated neutrino detector of considerable size, one million cubic meters in volume, which is located about 1,000 meters underground. The realisation of the project would lead to world-leading research and development in cooperation between universities and industry in Skåne, Uppsala, Värmland and Dalarna, as well as internationally. The investigations so far have shown that in Garpenberg, Dalarna has optimal conditions for such an establishment.

Elementary particle physics and accelerator physics is long established as a Swedish area of strength via the research and development activities of Swedish physicists' and engineers' at CERN in Geneva, from the very beginning of the laboratory's inception in the 1950s. Swedish engineers from Uppsala University, who participated in the building of the synchrocyclotron in Uppsala in the early 1950s, contributed greatly to the subsequent construction of the first accelerator at CERN in the late 1950s. Swedish physicists and scientists have since then been engaged in experimental particle physics and accelerator developments at CERN.

In recent decades, researchers from Uppsala University have contributed to the development of CLIC – the Compact Linear Collider project at CERN and the LHC accelerators.

The impressive FREIA Laboratory in Uppsala now has a mandate to develop and test new accelerator components for ESS and CERN. Tord Ekelöf, professor of elementary particle physics at Uppsala University has, since the 1990s, led Uppsala University's contribution to the development of beam monitors and other components for the Compact Linear Collider (CLIC) project at CERN, as well as a prototype of the superconducting dipole magnets for CERN's Large Hadron

Collider (LHC). Professor Ekelöf initiated the construction of the accelerator Development Laboratory FREIA in Uppsala, at which extensive development and test work for the build-up of the ESS accelerator is now under way.

One part of this project, and a prerequisite for its realisation, is that the ESS accelerator be upgraded in order to be able to generate short (100 μs) proton pulses. The existing ESS project foresees to deliver only long (3 ms) pulses. The upgrade of the ESS accelerator power from 5 MW to 10 MW, and the considerably shorter proton pulses and the use of neutrino detectors have great development potential for other applications at ESS, such as the examination of material structures, the development of accelerator-driven transmutation of fission reactor by-products, the irradiation of materials for fusion reactors, etc. Whilst these applications would benefit, it is a prerequisite for the neutrino experiment. The large neutrino detector could also be used for basic research on neutrinos from the atmosphere, originating from the sun and from supernovae, which is a very active field of research.

The establishment of the extremely powerful accelerator ESS in Lund, in combination with the knowledge of elementary particle physics and accelerator physics built up in Sweden, enables this extended research project with the Swedish world leading research to have significant impact globally.

As in the construction of Freia at the Ångström Laboratory in Uppsala, a spin-out effect is expected in the establishment of a number of commercially viable innovations that lead to new growth on a national and global market, as well as substantial growth in existing companies based on collaborations between Swedish world-leading companies and advanced research institutes. From a selection of similar initiatives, with particular reference to the developments around Freia, the growth effect is estimated to be a factor of 5. This means 250 people, on the basis of total employment in GRIPnu so the project would eventually generate 1250 jobs.

The staffing of the Gustaf Werner laboratory and the Freia and Ångström Laboratory is in its operational stage maximum amounted to 100 people. These research facilities have led to the establishment of new growth in Uppsala, which today employs 450 people directly in companies. It also has as many additional secondary jobs created as a result of activity in primary companies (called multiplier). In the particular case of Freia, this means a factor of 9 between the original number of rigorous scientific jobs and the outcome of the total number of jobs generated as a result[1]. For precautionary reasons, we prefer to deal with weaker dynamic effects for GRIPnu and therefore set this factor to 5. However, one should also consider that today there is a qualitatively different kind of support for commercial follow-up investments than was the case for the Gustaf

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[1] *Footnote: The CLIC and LHC accelerators are "particle colliders." The purpose of the construction of these accelerators having high energy and experimental precision will include improving the opportunities to study and understand the Higgs mechanism, i.e. the mechanism that brings about the Higgs particle. It is the missing link to the field of physics that explains how all matter is organised through the Standard Model.*

Werner laboratory and subsequent scientific investments. For the plant in Pyhäsalmi they calculated (in the operating phase) the employment of between 100 and 400 people, depending on the nature of the operational phase. GRIPnu and Pyhäsalmi are comparable facilities and we have therefore placed ourselves in the middle of this range.

For Garpenberg, which is a region characterised by gender-segregated labour markets, investment in research infrastructure is of major importance to break traditional gender segregation patterns. The establishment of GRIPnu in Garpenberg, together with relationships developed with universities and research institutions around the world, means that it will contribute to the creation of increased innovation and equality in the industrial structure of the region. In addition to other things, the Department of Physics and Astronomy, which will become an important cooperation partner, has only 10% of women researchers. However, the proportion of women among the students in the degree programme of Applied Physics in Uppsala is closer to 50%. That in itself is a positive indication that the percentage is rising. At the same time, we have good reasons to assume that a few of these women will choose a technical career in Garpenberg. In GRIPnu highly qualified female scientists will be active and visible. That women have a prominent role in high-profile projects is very important to attract women to the industry and the region. In this project, two highly qualified researchers Maja Olvegård and Elena Wilder participate in ESSnuSB and would be important role models in the region.

Business environment and interaction

The external analysis has been carried out by gathering information from a variety of sources. The feasibility study that is the basis for the application has extensive interviews with key individuals and the study of literature and the articles that have been produced in connection with the establishment of ESS in Lund. A "Fact Status" of research on neutrinos in different parts of the world has been drawn from scientific articles. In addition, interviews were conducted with representatives of the ESS.

CERN has previously generated neutrino beams and Swedish researchers have participated in experiments with them. Nowadays, CERN has no neutrino beam production and does not plan to have them in the future. This means that GRIPnu is the only project in Europe that is planning for neutrino beam experiments. Since ~20 years, Swedes have been active in the IceCube research project at the South Pole in which cosmic neutrinos are studied. The GRIPnu project will further develop the Swedish research tradition within neutrino research by offering new possibilities for experimental studies of neutrino oscillations, a research field for which the 2015 Nobel Prize in Physics was awarded.

There are currently three active and large-scale neutrino beam initiatives in the world. It is GRIPnu in Sweden, LBNE/Dune in the USA and Hyper Kamiokande (Hyper-K) in Japan. In the United States, after the demise of the SSC mega-project, the Superconducting Super Collider, government funding for research gradually shrunk. The existing neutrino project DUNE has the political ambition for non-American collaborators to bear half the costs. The project is thus dependent on support from other sources, which means that it is uncertain what will happen going forward.

In Japan, the Japanese government a few years ago suggested that a particle physics facility the "International Linear Collider" (ILC) would be built. This is about 10 times more expensive than the Japanese neutrino project Hyper-K and will require almost all available research funding (and yet still depends on financial contributions from the rest of the world). As long as the plant's future is not completely settled can the Japanese neutrino project Hyper-K will be on hold. In case that the ILC would be carried out, then, according to plan, Hyper-K would most probably be shelved.

If both Japan and the United States carry out their respective neutrino set-ups it would be difficult to implement GRIPnu. However, when both projects have great difficulties to overcome, the GRIPnu project is compelling. In an international context GRIPnu has great benefits:

- It has access to a superior accelerator.
- The existing assets significantly lower the cost of construction of necessary infrastructure. There you have access to the basic technology already in place in Lund (ESS) and Uppsala (FREIA) and mining and rock engineering infrastructure at the existing mine in Garpenberg.
- A superior physics capacity at the neutrino receiver i.e. the detector.
- Garpenberg is, unlike the project initiatives in the US and Japan, at the second oscillation maximum in relation to the radiation source, providing significantly better conditions for positive results.

However, it is actually an advantage for this type of unique research in the long run to be conducted in two different places in the world. They provide the opportunity to identify systematic measurement errors, compare results, calibrate the measurements and in various ways benefit from each other's measurements and results. Furthermore, the Ångström laboratory's joint development work with CERN and the mission they have to perform laboratory work for them ensures high quality technological capability at the cutting edge.

A lack of neutrinos

According to the cosmological Big Bang model of the universe an enormous concentration of energy seeded the development of particle-antiparticle pairs that were continuously created and destroyed. As the universe expanded, it cooled down, which meant that matter and antimatter, in exactly the same quantities, took more substantial form.

Gradually, however, particles collided with antiparticles that led to their annihilation accompanied by the emission of two photons. This is the same reaction as in positron emission tomography, PET, at our hospitals in which positrons - electron anti particles - are destroyed when they collide with electrons, and the pair of photons emitted are used to create an image of the diseased tissue inside the patient's body, in which a positron-emitting radioactive drug has first been injected and thereby concentrated in the diseased tissue. Despite this symmetric process, we are now in an asymmetric universe consisting only of matter and little antimatter.

This is one of the greatest unsolved problems in modern physics and cosmology. The current hypothesis is that a very small violation of matter-antimatter symmetry developed during the cooling down of the universe and led to the emergence of a very small fraction (parts per billion) surplus of matter, which is not annihilated by the otherwise universal annihilation of matter and antimatter to photons. One observable sign that this global holocaust occurred after the Big Bang is that there are about one billion more photons than protons in the universe.

Although the amount of residual matter is extremely small compared to that which was created shortly after the Big Bang, it now comprises all the matter that the whole of our present universe is made of. Violation of matter-antimatter symmetry of quarks (the constituents of protons and neutrons) was experimentally observed during the 1960s and can be explained by the Standard Model of particle physics (SM). But the observed quark-antiquark symmetry is far too small to explain the large amount of matter that now exists in the universe. SM cannot provide a solution to this problem.

The interpretation of new experimental neutrino measurements in China and South Korea, which was published in spring 2012, suggests that it most likely will be possible to measure the size of the neutrino-antineutrino asymmetry and that this asymmetry is about three times greater in the second neutrino oscillation maximum than the first maximum.

The new particle accelerator, which is under construction at the European Spallation Source ESS in Lund, could thus be used to produce an intense beam of neutrinos. These neutrinos, like the elementary quark particles, could be used for studies of key issues related to the asymmetry that we talk about above and thus the origin of the universe in the Big Bang. The studies are based on the neutrino beam being sent a long distance, about 500 km, from the production site in Lund to a sophisticated neutrino detector of considerable size - one million cubic meters in volume - located 1 km underground.

There is no doubt that such a high-tech, large-scale plant cannot be contemplated, planned and built without a comprehensive and long-term involvement of local manufacturing and service companies. A central question therefore for the project is whether the mine in Garpenberg can be used for the location of the detector and to what extent local industry and the local community could participate in and benefit from such an establishment.

ESS in Lund could realistically be adapted to produce this intense beam of neutrinos, which would mean relatively low investment costs together with a possible receiving station in Garpenberg where the second neutrino oscillation maximum is located.

Connection to the regional economy

Since the Middle Ages, or perhaps even further back in time, the mining industry - mining and smelting of ores - had a strong position in Garpenberg. Even today the mining and metals industry leaves a clear imprint on the region and much of the industrially-oriented part of the business sector in the region is in various ways linked to this story. The basic metals and mining industry is an increasingly fierce global competition and many have worked intensively to improve its efficiency, to stimulate innovation and to develop processes to maintain their world-leading position. This in turn has been a driving force in the development of several high-tech companies, a variety of companies that provide maintenance and services, as well as companies that process the materials. In addition, there is in the region a strong construction sector market in central Sweden and Mälardalen. It is estimated that about 80% of the competencies and capabilities required for the establishment of GRIPnu in Garpenberg could be supplied by companies in the area.

Description of the construction

In Kamiokande in Japan is the world's largest water "Cherenkov detector". The detector for ESSnuSB, that is planned to be built in Garpenberg, is technologically similar to the detectors that are in Kamiokande, except that the planned detector in Garpenberg will be significantly larger. The Kamiokande detector has a volume of 50,000 tonnes of water. The detector in Garpenberg is expected to contain 1 million cubic meters of water. The Kamiokande detector is located, just as for the detector in Garpenberg, near a mine. This is in order to use the infrastructure that is in place. The detector is located 1,000 meters underground and is reached by a 1.8 km tunnel that is large enough for bigger trucks.

The detector in Kamiokande is in the form of a cylindrical steel tank having a diameter of 39 meters and a height of 42 meters. The detector can be reached by four pressure-sealed doors, two on the top and two at the bottom. The two at the top are used as a platform for electronics, calibration, water control, etc. Along the walls of the tank is a stainless frame that holds 11,000 photosensors in place. Each photosensor is connected in parallel to the top of the tank and the detector control electronics. The detector in Garpenberg consist of ~100,000 photosensors.

There are great demands on the purity of the water that is in the detector tank. The detector will require so-called UPW. This means a purity of the water that has an absorption length to light of about 100 meters. The water in the detector tank is cleaned continuously and once a year is emptied so that the whole area can undergo service and maintenance.

In order to keep pollution away from the detector there are airlocks into the detector and the pressure around the detector is supplied with air from the surface. From the Kamiokande detector the results and data are sent via a five kilometer-long fibre to the plant's laboratory where the data is analyzed, processed and stored.

The new particle accelerator, which is under construction at the European Spallation Source ESS in Lund, can be used to produce a beam of neutrinos that are sent 500 km from Lund to the detector in Garpenberg. The placement of the detector in Garpenberg is not random, but rather the detector is located where the second neutrino oscillation maximum is.

Competences and resources

The opportunity for local businesses to deliver large projects are affected by several factors, including political factors. Political factors set limits on how and to what extent procurement should be done in the host country. During the construction of the ESS it is estimated that 50-60% of the contracts will be placed without being procured. The supply process of in-kind contributions means that member countries finance their participation by supplying equipment instead of money. This compares with the construction of MAX IV, where about 90% of construction and 76% of the equipment/machines are supplied by Swedish companies by procurement procedures. One reason for this high proportion can be that MAX IV has grown organically and been developed over 30 years. "Generally, we can say that a supplier's geographical distance during the construction and instrumentation phase increases in proportion to how technologically advanced a requested product or service is." (Source: “Growth will not happen by itself”, p. 8).

Conventional buildings, such as excavation, concrete work, etc.

The main buildings are usually not covered by in-kind agreements, but are procured on the local market, which is an opportunity for local businesses to become suppliers to the project. Within this category all the components are not of equal degrees of specialisation, in contrast to the procurement of technical and scientific equipment. The challenge for local businesses will be to be able to deliver the volumes required.

Before the construction of ESS and MAX IV some areas where local companies were considered to have a great opportunity to win contracts were identified. Specifically mentioned were installation, environmental technology and transport. These are also areas where the need will be the greatest for the construction of a detector in Garpenberg. Other areas where local businesses have a great opportunity is in maintenance, stainless steel welding, carpentry, and electrical installations.

In the investigation that Ramboll made for the possible construction of a detector Pyhäsalmi in Finland an opportunity for a regional market of simple parts in the actual construction, national major players in the planning, design and larger contracts and international players in the high-tech contracts related primarily to the research facility equipment were identified. It was remarked that the regional industry's share would be higher when the facility moved into the operational phase. Those activities which were expected to emerge in the construction phase were the concrete industry, operation and maintenance, chemistry, mechanical engineering, logistics, mining contractors, construction, engineering, industrial consulting, electricity, housing, IT, and research activities. There is no apportionment to each area specified in the report.

One sector where the report foresaw an increase during both the construction phase and the operational phase of the project was the hospitality industry. During the construction phase, it was estimated assessing that temporary housing for 100-200 people would be needed. During the operational phase, this was estimated to be ~6000-9000 annual overnight stays. At peak periods, as for example during scientific conferences, there would be the need for 100-200 beds.

While local companies would be the suppliers to these large projects, there is no guarantee that the workforce would be local. It is increasingly common for labour to move to where jobs are available. It is common primarily in construction and mining operations where weekly commuting can be a prerequisite for obtaining a job. When the plant is completed, it will evolve and be in need of continuous need of service and maintenance. This gives any company that is experienced an advantage over other companies during the construction stage to secure contracts, and even in the operations phase as is seen in other large research facilities.

In cases where there is a requirement for procurement of expertise and resources, it is not uncommon that only large national/international companies are able to bid on these contracts due to their scope and complexity. In these cases, there is nevertheless an opportunity for smaller companies to enter as second or third generation suppliers to these bigger companies. This has been the case with purchases at MAX IV where the construction has been a collaborative project where different sized companies sit together in a cluster. Examples of companies that are directly involved in the procurement of the construction of MAX IV is Peab, Tyréns, Sweco, Sydtotal and NVS.

Whether they deliver directly or as a subcontractor, it is important that early planning and working towards cooperation, for example in a consortium with several companies with complementary resources or to jointly achieve the skills and capacity requirements that are often required as a supplier to major research projects. Here, cluster leaders - the region itself and key organisations - have an important role to prepare, educate and connect businesses for them to have the opportunity as an individual company or together in a constellation to bid on tender calls.

For the convenience of local businesses advice can obtained from IDC South who work to support local companies to deliver to the research facilities ESS and MAX IV. This has for example included information on business opportunities/procurement, skills development and has stimulated business cooperation.

For the construction of a large neutrino detector in Garpenberg, knowledge in a wide variety of areas is needed in order to interact and evolve to lead to construction contracts. The whole project will represent a leap in technology. Knowledge of traditional mining will interact with the world's leading researchers in the fields of elementary particle physics and accelerator physics. In many cases, for local expertise, the challenge is to scale up - for example, water, materials and underground construction - to the scope and requirements needed for the huge installation, which requires that equipment must in many cases be developed and specially manufactured.

In comparison with other research facilities it can be concluded that local companies often have an advantage over their competitors on the basis that they have a lower cost of living, favourable technical specification requirements and that local businesses are often, at an early stage, able to get information about the project and then be well prepared.

Inventory of skills and resources in the local area

To make an inventory of what local resources are available for the construction of a research facility with this large detector in Garpenberg is complicated by its possible construction far into the future and that the construction process will last to up to seven years. This means that the business structure during this time will change, so it can be difficult with the inevitable technological development to predict which technologies and services will be needed for the project at that time. A rough estimate can be made that ~80 percent of the necessary human resources and knowledge are available in the region. It will not however be the case that 80 percent of the total budget of around 700M€ will end up in the region. This is partly because the detectors themselves account for half of the budget and partner countries choose to fund projects through so-called in-kind, which is the case with equipment.

The Construction process can be divided into four phases: Project Design - Blasting - Installation - Operation.

Design

The design phase comprises the following steps:

- Investigation of pressure and strength in the bedrock.
- Calculations and design of the cavity in the rock that will host the neutrino detector.
- Planning and design of underground service areas and access tunnels.
- Assessment of permissions required from the appropriate authorities.

The bedrock

A "Memorandum of Understanding" has been signed between Uppsala University and the mining company in Garpenberg, which broadly signifies that Boliden gives access to the area where the neutrino detector will be built, as well as access to Boliden staff for consultation. The project has had access to all Boliden documentation concerning the area where the detector will be built.

A first test drilling has taken place in the area, in collaboration with Boliden, where the detector will be built. The results have shown that the area continues to be iideal for the construction of the detector. In order to progress with the project design, an informal cooperation has been initiated between Uppsala University and the Mountain School in Filipstad/Luleå University. Filipstad/Luleå University has offered to provide expertise in areas such as pressure, strength calculations, point load testing and the analysis of drill cores.

In order to carry out the project an estimated 15-20 drill holes of approximately 1,000 meters will be required. The drilling method used is called core drilling (Core drill). An assessment has been made of the continuing investigations today, and no further permissions are necessary when the test drillings are in the Boliden area and these conditions apply today. In contrast, it is necessary that private landowners who have land above the areas where drilling will take place should be informed.

When the time comes for construction an Environmental Impact Assessment (EIA) and stakeholder consultation will be required. This process is not expected to encounter any obstacles given that today's mining operations in the area and its business has no environmentally hazardous activities. The focus during the permit authorisation process will be on the disturbances that arise during construction, as well as where to dispose of the rock mass crushed and brought to the surface.

Examples of local companies:

No local companies with expertise in core drilling are in the immediate region. The leading company in Sweden is Drillcon Core AB, registered at Nora. Drillcon has carried out a number of contracts for Boliden, including core drilling in the Garpenberg mine. It was Drillcon that drilled the pilot hole penetrating into the area where the detector will be located. In addition to Drillcon Core there are a number of small Swedish companies with equipment and expertise in core drilling.

For the implementation of the environmental impact statement there are a number of companies available, for example, Sweco, ÅF, LRF Konsult, Wing, Ramboll, and Mannheimer-Swartling.

Blasting

The blasting phase comprises the following steps:

- Blasting of rock areas, service areas and access tunnels.
- Upward transport and disposal of crushed rock mass.
- The lining of the excavated cavity walls with concrete and steel bolts.
- Treatment of the excavated cavity walls so that they are completely watertight.

An estimated 1.6 million cubic meters of rock have to be blasted and transported up to the surface. As a result of this activity, ramps, tunneling, lifts, and rock chambers with associated areas will need to be constructed. One advantage of Garpenberg is that it already has access to the 1,000 meter level thanks to the mining that has and is still taking place in the area. This would otherwise cost an estimated 50 M€ and require at least five years of work if the mine did not exist.

Examples of local companies:

In recent years, the industry has consolidated and the biggest Swedish company that makes the shafts is Bergteamet based in Boliden. No local companies exist with the knowledge and resources for the blasting of ramps, drifting, lifts and caverns. The companies that are active in Sweden, are Veidekke and the Austrian company Strabag. In addition to these companies, Peab and Skanska have activities in Northern Sweden.

Installation

The deployment phase comprises the steps of:

- Construction of racks along the walls for mounting the photodetectors.
- The installation of the photodetectors.
- The installation of high-voltage and signal electronics with cables to the photodetectors.
- The construction, operation and maintenance of pumping systems and water treatment plants.
- The construction, operation and maintenance of the underground control room with computers and digitising electronics.
- Installation, operation and servicing of various monitoring sensors and control electronics.
- Installation, operation and servicing of security systems and monitoring systems.
- Installation, operation and servicing of ventilation and groundwater pumps.

Water

The detector itself is a stainless-steel tank that is 100 meters high and filled with 1 million tons of water. The scaffold edges ensure a stainless location into which the detectors are installed.

Examples of local businesses:

Production of stainless steel: Sandvik and Outokumpu are two local companies who produce stainless steel.

Profiling sheet: Ortic, Jonsson and RPM.

Mechanical installation: Bergkvist, Svets & Mek and Bäckströms Mechanical.

Construction under and above ground: There are a number of small and large local companies available.

Water treatment

The detector will require so-called UPW. Which means a purity of water that has an absorption length to light of at least 100 meters. The detector will contain 1,000,000 cubic meters of water and require continuous water treatment, at a capacity of ~1000 tons water/hour. The wastewater treatment plant in Kamiokande is well tested and documented. The detector in Garpenberg will require a water treatment capacity that is 20 times greater than that in Kamiokande. The volume alone will require a lot of innovation. Data from Boliden show that there is a low water flow, which will make it a challenge to ensure the detector being filled up in a reasonable time for example. A possible solution could be to have three detector chambers where water can be pumped between the different volumes and exchanged during service.

Examples of local businesses:

The Falu-based company Pure Water Scandinavia AB plans, designs, deploys and services water treatment plants. The company matches well the quality requirements of the plant. They have previously delivered equipment to the Karolinska Hospital, The Biomedical Centre in Uppsala and the MAX IV Laboratory. The amount of water to be purified in connection with the filling/refilling of the detector makes great demands on the capacity of both pumping and purification, as Pure Water Scandinavia or any other international company has not previously built such scale of facility. The technology has been well tested and evaluated by the facility in Kamiokande. The water treatment facility in Garpenberg will need to be scaled up 20 times in relation to the Kamiokande to meet the ESSnuSB plant's requirements and be able to supply the detector with water.

Ventilation and heating

During some phases of the building process it will probably be possible to make use of Boliden's ventilation system. When the detector system goes into its operational phase, the plant must have its own ventilation and heating system similar to the systems built for the mine to extract air via ducts and channels built for this purpose and vented to the elevator shaft or via specially drilled ventilation shafts.

The detector and the environment around it is not in need of clean room classification. However, it is required that the air that comes into contact with the detector is kept free from background radioactivity in the bedrock. This is done by maintaining a slight overpressure in the facility and using airlocks.

Examples of local companies:

Bravida, Imtech

Electricity and Automation

The detector will require extensive electrical, fibre and data installation work. This includes the parallel connection of 100,000 photo sensors to the control equipment, data storage, electricity, fibre connections. From the control room operators should be able to monitor and control the entire plant including water treatment, ventilation, the detector, time synchronisation, etc. This requires a comprehensive electrical and automation work during the construction period.

Examples of local businesses:

There are a number of local companies with expertise in electrical, control and automation. It is likely that in this area a consortium of several companies will be working on the installations. These comprise big companies such as ABB, Midroc, Assemlin and Bravida to smaller local companies like Trelco Belo Electric. Midroc has experience in areas such as automation and industrial IT. Another division of Midroc is focused on, among other things, heavy steel structures and their building as well as maintaining large cisterns and tanks in stainless steel. Midroc has mining expertise and experience working with large mining projects, including Garpenberg. The early days of Midroc started with a rock cavern project aimed at creating underground storage facilities for refined petroleum products in Saudi Arabia. The businessman Mohammed Hussein Al-Amoudi was awarded the contract in cooperation with a number of Swedish companies. To carry out this gigantic project a number of companies was acquired and launched, both inside and outside Sweden. To create a structure bringing together all the companies that were involved in the construction of the cavern Al-Amoudi engaged Lennart Wikström Group Midroc Europe, in 1996.

The companies have since developed individually, and new companies have been added to the Group. The Group's business is now in real estate, the construction industry and the environment. The business areas include a number of specialist areas such that the future GRIPnu project might engage. Among other things, Midroc Rodoverken is the market leader in site-built atmospheric tanks and pressure vessels. The company has developed a proprietary method, the so-called screw method, which is more efficient and safer for the construction of tanks and tankers. Midroc Rodoverken was founded in 1944 and has since developed this unique construction method that fixes the tank from the ground during construction. The method increases the efficiency as well as safety. The method also facilitates the servicing of the completed tank.

Operational phase

The exploitation phase comprises the following steps:

- Maintenance, repair, servicing as well as emergency servicing *in situ*.

- Operation of the plant.

The plant is controlled by an automated control, monitoring and data collection system such that the data can be processed in different places in the world. The plant will have both permanent staff and contract personnel. External expertise will be needed for servicing and maintenance of plant parts such as the ventilation, the water system, electricity, automation, security, and maintenance of the detector.

Examples of local companies:

In addition to the above-mentioned companies under each heading, there will be an opportunity for local businesses that want to become specialists in the management and operation of this particular plant.

Development of supplier systems and networks

The region has for many years undertaken to maintain and strengthen Garpenberg steel and engineering activities. Specifically, Industrial Development Dalarna AB, which has worked with development projects aimed at the steel, engineering and construction industries since 1997. It is currently managing the EU project "Sustainable supply chains", which aims to strengthen the value chain from the supplier to include steel industries by supporting the companies in the chain that currently do not have their own research and development resources. Another example is the innovation environment Triple Steelix, which has been financed within the framework of Vinnova Vinnväxt programmes since 2004. In addition, Innovation Environment is working to further develop the Swedish areas of strength in steel and engineering.

These initiatives have been proactive in the development of the sub-network where small businesses grow together in order to be considered for the large corporate procurement exercises for services and products. The networks ave all involved one or more large companies, eg Boliden (Garpenberg Mine), Outokumpu (Avesta), Erasteel (Hedemora Municipality), Sandvik (Sandviken), ABB (Ludvika) and Ovako (Hofors and Smedjebacken).

A key driver in recent years of industrial development in the region has been Boliden's investment in the Garpenberg Mine, where approximately 390M€ has been invested in recent years. The mine itself is one of the world's most cost efficient and modern mines. This investment has resulted in the growth of small and medium-sized enterprises and a number of development projects that have benefitted from this expansion.

Purpose

The GRIPnu project has the following objectives:

- Take the first step towards the establishment of already world-leading Swedish research in another scientific field through the development of the ESS structure and existing forms of cooperation into a network of national and international research capabilities.
- To investigate how the technical solutions can materialise in Lund, Uppsala and Garpenberg to allow the beam of neutrinos that is emitted, to be detected and analysed.

- To strengthen the ESS in Lund as an international research node by adding another world-leading research area to what is already under construction.
- To realise a cross-border cooperation in the Triple Helix form where the relevant ministries, regional councils, research projects and research institutions and companies, at the multinational regional and local levels can be involved.
- To contribute to the realisation of the agenda for smart specialisation in Dalarna and Skåne.

Some key issues in the project's initial phase are whether the mine at Garpenberg can be used for the installation of the neutrino detector and how regional industry and regional society can contribute to and benefit from such an establishment.

The project enables multiple interconnected priorities.

- First, it contributes to what has been set as a desirable effect of the ESS project, it will generate sustainable growth across the country with cooperation between companies, researchers, universities and other public entities as well as cross-border projects between Swedish regions.
- Second, it is an important step toward establishing another world-leading research discipline in Sweden.
- Third, it provides opportunities for the spread of the world's leading research and technology in Uppsala and Lund to the geographic areas in Sweden which currently have weaker growth.
- Fourth, the existing network of the leading mining companies in Central Sweden (eg Boliden), and their technical suppliers and academia (such Bergsskolan/LTU) will, in cooperation, be given the opportunity for the development of breakthrough technologies in rock and mining in the design and construction of the gigantic volume in which the detector will be located.
- Fifth, other businesses in the region will be given the opportunity to take part in a considerable volume of assignments and, in connection with this, take significant development steps and be able to compete in new markets, which also strengthens the growth in a region with weak growth. Studies of the consequences associated with the establishment of CERN, MAX IV and ESS shows that a) 80% of the order volume of goods and services awarded to suppliers within a radius of 100 km from the facility and b) a number of smaller suppliers, by obtaining advanced orders, take a major development step and thereby qualify for other missions with very high demands on technology and precision.

The project provides opportunities to meet some of the measures mentioned in the national programme investment priority 1a of the ESS, such as "The node is geographically in southern Sweden, but will work for the sustainable growth of the country. Collaboration between companies, researchers, universities, and other public actors will be conducted both in the region and also between regions throughout Sweden."

In the National Regional Fund programme 2014-2020 the following is stated: "In the eight regions, Structural Funds are available now as in the previous period, leading to the possibility of cross-border projects between regions and programme areas. During the programme period from 2007 to 2013, however, fewer projects than expected were carried out. Therefore, efforts have been undertaken to stimulate cross-border cooperation at both the regional, transnational in those sectors around the areas that constitute Swedish areas of strength. The configurations that can be considered for funding in the investment priority should be nationally and regionally identified. The aim is to create innovation through this collaboration, and thereby add value to ongoing initiatives. The programme will add value to existing initiatives, preferably through increased intersectoral cooperation across regional and national borders."

Goals and Results

Overall goals

To actively contribute to the effects of the ESS in Lund being spread to North and East Central Sweden. The project thus leads to enhanced attractiveness and the business innovation and growth potential in Central Sweden is improved and the project is developed into a recognised good example of cross-border cooperation, both geographically and between research, entrepreneurship and community development.

Project

Build up a number of collaboration platforms for open innovation, where high-tech companies, researchers and politicians together build "infrastructure" for the future establishment of GRIPnu and investigates in detail the conditions for its establishment in Garpenberg.

Intermediate Targets

• To carry out geological investigations (boreholes and analysis) that confirms the physical conditions of the underground establishment.

• To form a steering committee, working with leading national decision makers (scientists, business leaders, politicians), which is responsible for the anchoring of the project at the international level.

• To establish an industry consortium (already begun)

• Forming supplier networks with companies from central Sweden and Skåne in relevant areas

• To develop R & D collaborations between the different stakeholders (eg UU, LU, KTH, Chalmers and the University of Dalarna)

• To develop a strategy to identify opportunities for commercialisation, resulting from the project. To enhance experience and knowledge collected from other major international scientific investments, where commercialisation opportunities have been tangible. Innovations that occur within the product and service areas will contribute to smart specialisations based upon the site-specific areas of strength.

• To establish contact with the region's educational institutions to implement cooperatively activities that will increase interest in training in science and technology.

Target group(s)

Target groups of the project are companies, researchers, innovators, regional educational institutions and public actors that can affect or be affected by the future establishment of GRIPnu.

Expected results at project conclusion

After the project has been carried out the expected results are the detailed information needed to take the next step in the process of establishing GRIPnu. Within the framework of the project budget there are not sufficient funds for the technical analysis necessary to produce this evidence. We expect that the steering committee and the collaborative platforms developed under the project will also contribute to the financing of the parts of the project that the budget cannot bear. Through the collaboration platform and after the project implementation the necessary evidence to determine these factors will be ascertained. The project will build up a number of collaboration platforms for open innovation, where high-tech companies, researchers and politicians build "infrastructure" together for the future establishment of GRIPnu and investigate in detail the conditions for the establishment in Garpenberg.

Expected long-term effects

Direct and indirect effects

The effects that the establishment of major research facilities in a city or region can bring can be divided into the direct and indirect effects.

The direct effects are the creation of additional employment and the demand for goods and services. These direct effects are produced both during construction, and when the plant is operational via the purchase of equipment and services. These have a direct connection to the establishment of the facility. Direct effects are often detectable for example in the number of jobs and are rather predictable.

Indirect effects are broader in their variety and are more difficult to measure and consist of the plant’s influence on technological development, innovation, climate and other spin-off effects on the local and regional economy. The indirect effects arising as a result of the investment are such as the ability to attract highly skilled workers to the region, the prestige effect of putting the region on the map, new businesses and innovation unpredictable effects. The indirect effects have a greater geographical spread than the direct effects. The two kinds of effect have different impacts according to where in the process the project is in (such as planning, construction, commissioning or operation). "The long term indirect impact is the most crucial and the largest. If this does not occur, the impact on the region's growth is marginal. " (Source: ESS in Lund - effects on regional development, p. 12) A number of studies have been made on indirect and direct effects which show that indirect effects are often the most important (eg, ITPS, 2005).

A study was made concerning the possible construction of a neutrino detector in Pyhäsalmi in Finland. The report assesses the direct and indirect jobs created during the construction phase, which is estimated to be between 2,700 to 4,200

FTEs during the 10-15 years building phase. The number of persons employed in construction is estimated to be ~100-400 people depending on the stage of the construction.

When the facility in Garpenberg is operating some 100 people will be responsible for its operation and maintenance, in addition to some 20 researchers who succeed each other at the facility. In addition, another 100 people will be located in Uppsala, Lund and other labs around the world. The plant will have an impact on the community and the region. How big this will be is difficult to estimate when the plant is in place and operational. Some indicators can be obtained through the use of the so-called multiplier which is a coefficient indicating how much the social impact of direct employment in the set-up generates in the region.

In the report "Planning and transport infrastructure with ESS and MAX IV" it is assumed that the construction phase of the ESS and MAX IV will result in ~30% of the investment benefitting the region, including in the form of wages. The same report also shows that the multiplier effect is estimated to 3.8. This means that a full-time job at the research facility (direct effect) generates an additional 2.8 jobs (indirect) effect in the region. Sweco has made an international comparison in the report "Strategy Surface ESS and MAX IV - Interim Report 1 - International case studies of 5 environments." where they have analysed the scientific establishments in 1) Oak Ridge National Laboratory (ORNL), 2) Brookhaven National Laboratory (BNL) in USA, 3) Organisation Européenne pour la Recherche Nucléaire (CERN) in Switzerland, 4) European Synchrotron Radiation Facility (ESRF) in Grenoble, and as a benchmark the development of 5) Luxembourg. In the report, they pointed out that a multiplier of 3.8 is generous and that a figure of between 2-3 is probably more realistic. In the same report, it is written that in addition to direct and indirect employment, other effects arise a) Human Capital Effects b) Externalities and c) Regional attractiveness.

Human capital effects consist of non-employee researchers being seconded to the facility for longer periods of time working with advanced instruments and experiments, and thus build up a specialised knowledge, which often spreads outwards and benefits other regionally based activities. Another example of the effect of human capital is the scientific plant's positive effects on education in the region acting as "inspiration" and motivating an increased interest in science education and the use of the facility of by primary education and secondary education in the region. A fair evaluation from the regional policy point of view is the impact on the regional knowledge infrastructure.

Externalities consist of human capital spill-over between companies of specialised workers who change jobs, or where these employees start new businesses (as in the case of Uppsala below) where (parts of) the technology are spun off into a new company. An example of externality is related to the development of the mobile phone industry which has led to new markets and competitive advantages created for the music industry. Therefore, collocation in a regional innovation environment or in clusters, play a positive role. It is therefore reasonable to assume that the externalities generated by research at GRIPnu will accrue to companies in Dalarna and its neighbouring counties to a greater extent than companies that are not located in the region.

The regional attractiveness of the facility also attracts spin-out establishments. In all case studies, we find that major international companies have established subsidiaries in the vicinity of the large infrastructures. This leads to a kind of self-reinforcing accumulation effect or clustering. The more similar or related are the companies and researchers who establish themselves in the area, the greater the positive external effects as well as enhancing expectations and confidence. The region thus becomes an attractive alternative location, not only for companies whose activities can directly benefit from the ESS and MAX IV, but also for suppliers and related businesses of various kinds. These include conference activities and similar "secondary" uses that the plants may generate when they are in operation.

To take advantage of the potential effects that may arise from such an establishment, it is important that an attractive and dynamic environment is created where meetings can take place that lead to new innovations, businesses and jobs.

"The biggest risk with the ESS project is that the actors in the region fail to take advantage of all the opportunities that the facility, combined with the MAX IV, generates" (Source: ESS in Lund - effects on regional development, p. 14).

Business impact is often more indirect and more difficult to quantify. This is true both in the sense that regional knowledge transfer between facilities and companies can be very large without a single company formally demerging from the facility and partly in the sense that the plants indirectly benefit a range of industries simply because the region's brand has improved or amplified.

Multiplier effects in scientific investments

It is not possible to predict exactly which technology areas will benefit from using the facilities in the future. With previous large scale research facilities, just a few decades ago, no one thought the idea that scientists and life science companies would have use of the facilities, and yet today's life science industry is one of the primary uses. Our ability to anticipate technological developments has hardly improved, in that despite the fact that technological development has increased, we have to assume that the scientists at those research facilities that are planned at this time will be even more surprised by the future uses than were previous generations of researchers.

Perhaps the best and most telling example of unexpected dynamic effects of purely scientific establishments is with the founding of the high energy nuclear physics laboratory at CERN which led to the creation of the World Wide Web. This was not a planned act but resulted from a tool that proved to be necessary for the development of research at CERN by the distribution of data to facilitate their interaction with researchers around the globe.

Another example is the development of semiconductors which led to high-speed computers and a few decades later this computing power enabled the sequencing of DNA which led to significant advances in health sciences.

A third example, on a small scale, is the development surrounding the establishment at Uppsala University in the 1950s of the Gustaf Werner Institute (GWI) accelerator laboratory. Although this was a purely scientific facility that conducted basic research during the period from 1976 to 2001 four spin-off companies were established. These spin-offs were the result of a number of individuals' own initiatives, without public support, incubators or other business promotion. Companies such as GE Healthcare (GEMS PET Systems AB), Elekta Instrument AB, ScandiNova Systems AB and Gammadata Instruments AB have seen strong development and currently employ a total of about 450 people (without including subcontractors) with a total turnover of 180 M€. If we include subcontractors and surrounding effects the total employment created in Uppsala alone could well be over 1000 people!

Common to all the above examples is that they have occurred as a result of purely scientific processes and without government assistance. In many cases, they have even been actively opposed by the academic world, which has not always been positively disposed towards the commercialisation of academic activities. Had the above scientific investments been made today the commercial impact would probably have been far greater than those reported above, given the commercial awareness and active support that is available today for the commercialisation of research. Knowing this, the innovations generated by GRIPnu will be handled in a completely different way, with an active process centred on proven methodology concerning the commercialisation of such innovations.

It is sometimes argued that priority be given to applied research on proven commercially viable fields rather than so-called pure research. It is a valid point, but one which overlooks the fact that commercial activities will only be identified in areas that are already known, while basic research generates results in areas that were not known or were unexpected before the start of the research. Sometimes these research results are commercialised quickly, while in most cases they act as important elements for future commercial developments in harness with new technological breakthroughs (eg. the role of semiconductors in DNA analysis).

Organisation and implementation

Project Organisation

A steering committee will be appointed with representatives from the different funding agencies. The steering committee will have overall responsibility for project implementation and the anchoring of the project in the region. Members will be active in the establishment of the Innovation Platform and the interaction configurations that will result from the project. The Steering Group will meet ~4-6 times per year. A full-time project manager will be recruited. The project manager will have operational responsibility for the implementation of the project according to the established plan. A detailed action plan will be developed via a workshop with the project manager and the steering committee at the steering group's first meeting. Specialist skill needs such as lecturers, knowledge donors and leaders of various sub-projects will be procured externally. Monitoring and evaluation is to be handled internally by the project manager. External support will be procured or supplied to the project using internal expertise as necessary.

The project will actively work to take advantage of the innovations in different ways that can contribute to this goal. As an example, Hedemora Municipality has started working towards a more effective and gender-assured integration of newly arrived personnel. Hedemora Municipality Diversity Strategist, Maria Lundgren, will be assigned to the work to participate in the project focusing on both integration work and gender equality. This means that the project will be implemented in close conjunction with the ongoing integration work already taking place in Hedemora. Among other things, the technology shift that industry is now experiencing is being discussed and embraces minority groups. Innovative methods for the integration of new arrivals by employing the use of social business is part of the municipality's planned work to equip newcomers and employers for internships and jobs. These "best practices" and other initiatives will be highlighted and disseminated within the collaboration platform.

Working groups will be established to work with the different aspects of the project. The working groups will be staffed with representatives from science, business and public sectors. Initially they will focus upon the following fields:

- Innovative methods and models for competences in the use of new technologies such as simulations.
- Development of "tools" to attract more women and people with non-Nordic background into training for work in the mining industry.
- Development of methods and models to improve the working environment and safety in the local industries.
- Innovative models for supplier networks to meet the needs of the mining industry for services and maintenance, as well as product development, etc.

The evaluation will be conducted in accordance with Tillväxtverkets instructions which includes self-evaluation:

- Project logistics via careful documentation and reconciliation against targets.
- The process of doing surveys.
- Public debate by following up the project's attention in the media and during development and construction activities.
- Polls will be used to evaluate the key actions.
- All staff will be interviewed twice during the project period to obtain their feedback.
- Key indicators will be measured through statistics and possibly also through interviews.

When appropriate, external expertise will be procured for the implementation of certain parts of the outreach programme. Alternatively, these activities will be supplied resources in the form of internal expertise within the company.

The Project

Hedemora Business AB (HNAB), which is also responsible for the feasibility study, will be the owner of the project and thus carry the ultimate responsibility for the project. The company is wholly owned by Hedemora Municipality, and the responsibility of the municipality is to accelerate growth and business development. HNAB has, since its inception in 2002, designed and implemented projects in many different areas. These have been facilitated by funding from the EU's regional and social funds, via national programmes funded by the Growth

Board, by Region Dalarna, the County Administrative Board and others. Amongst HNAB's projects has been a project aimed at promoting equality, diversity and to improve the environment. HNAB is currently participating very actively in a project funded by the Asylum, Migration and Integration Fund (AMIF) aimed at assisting refugees. This is a Hedemora Municipality project. Overall, Hedemora Enterprise AB has extensive experience and a solid knowledge when it comes to running and managing projects. Within the organisation are highly competent people in all the so-called horizontal criteria that will be utilised in the implementation of the project. There are synergies between GRIPnu and AMIF-funded initiatives for example "A way out", which among other things will help with diversity skills. Another project is that of the "Mining Town", financed by the European Regional Development Fund, which aims to build an innovation platform for the mining industry in central Sweden.

In case the application process for this Call has been such that all co-financing has not been possible to arrange before the submission of the application Hedemora Enterprise AB, the majority of co-financing ensures to cover it. During October and probably well into the month of November the project team will work on contacts regarding co-financing that has arisen during the feasibility study. The goal is that all cooperation certificates will be signed in mid-November.

The project owner has the ultimate responsibility for the financial economy, and to ensure that the project is implemented in accordance with the application. HNAB is also responsible for contacts and meetings with Growth Board and other co-financiers during implementation.

Steering Committee

Opportunities to meet the long-term goal, i.e. to finance and build a unique research facility in Garpenberg, depend upon political decisions at the international level. The form of financing is expected to largely resemble the approach that is the basis for the construction of ESS in Skåne. There is much to learn from work with the financing and construction of the ESS as it is important to take advantage of this knowledge as it is built up. Specific activities will be undertaken in the project to take advantage of these experiences. Efforts to build up international contacts will be the responsibility of an operational steering committee with decision-makers from academia, politics and business. The steering committee will be responsible for building relationships with funders and other partners who can work for the project as it is established. This is of course subject to further work on analysing the bedrock and other conditions in Garpenberg, that hopefully verifies the assessment that it is a suitable place for the detector location.

The steering committee will, in addition, oversee the operational phase as described above, having the customary responsibility for decision-making regarding routing, prioritisation of actions in the project and, together with the project manager, in driving the project forward. In summary, the steering group will have a much more operational role in this project compared to many other projects.

Project management and external resources

A process manager of will be recruited on a 50% basis. This person will have the role of coordinator of the steering group's work and be responsible for the implementation of planned activities. However, it is important that the project development process will be flexible. As an example, we do not yet know how many drillings will be needed to be able to reliably determine the suitability of the bedrock. The intention is also to continuously work on innovation processes that will allow new technologies to be examined when appropriate. The steering group will be responsible for the choices and priorities between different activities at any given time.

Specialist manpower will be procured in accordance with Hedemora Municipality's procurement policy. The Procurement Plan is attached to the application. Regarding the evaluation and learning process, a manager will be responsible for monitoring and continuous evaluation of such activities and initiatives. An external evaluation will be procured by the end of the project although some limited external evaluation efforts are planned for 2017 and 2018.

Work to be carried out

The project will be characterised by a process-oriented approach, where the steering committee, together with the project and cooperation partners, will carry a heavy responsibility to make choices and assess the various interventions important to the long-term goal of establishing a unique research facility in Garpenberg. The preliminary study has shown that it is difficult to assess the need for action to ensure the suitability of the bedrock.

The project can be divided into a number of distinct parts:

- Implementation initiatives - with mainly known techniques - to verify the suitability of the site.
- Conduct design studies in which new technologies, knowledge and innovations are developed and tested.
- Build relationships and networks with decision makers, both nationally and internationally.

Within the framework of the completion of the feasibility study, the work in the three areas above has already commenced. These are now continuing their efforts to clarify the conditions for the establishment in Garpenberg. In topics 1 and 3 work has already started. In the 2nd topic relationships with the many players who have ties to the mining industry, within the framework of the preliminary study, has already been established. They concern individual businesses, educators, research agencies, industry associations and suppliers. Building up the innovation platform for the exchange of experience and cooperation are the pillars of the project, and this work must continue. There is, in the original feasibility study, a solid foundation for the viability of the basic ideas and the planned activities in the project. However, the facility as planned for Garpenberg should be sustainable and address the needs of all stakeholders, so that these dialogues must be continued and further developed. It is important that this work is carried out with broad support and consensus on how the facility will be built and the programme plan implemented. It is also important to ensure that all operations are implemented according to the requirements of the different actors taking into account their judgments about industry's future challenges in the region.